Biological Conservation 142 (2009) 3213–3218

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Short communication

Evidence-based decisions on the use of predator exclosures in shorebird conservation

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ARTICLE INFO

Article history:
Received 25 February 2009
Received in revised form 29 July 2009
Accepted 30 July 2009
Available online 27 August 2009

Keywords:
Piping plover
Predation
Exclosure
New Jersey
Fencing
Nest success

ABSTRACT

Conservation practitioners often rely on experience rather than scientific evidence when making management decisions. These experience-based measures can waste limited time and funding if the given conservation practice is ineffective. Unanalyzed conservation strategies may negatively impact the species that is being protected. The use of predator exclosures to increase hatching success in ground-nesting shorebirds has been studied for almost two decades, yet their effectiveness is still debated. In ecosystems where predation pressure is particularly strong, electrified exclosures have been adopted; however, there are no studies on their efficacy or potential negative impacts. We conducted a nest survival analysis for 10 years (1998–2007) of piping plover monitoring data to determine: 1) the effectiveness of predator exclosures and electrified predator exclosures, and 2) conditions associated with nest abandonments at electrified exclosures. We found that predator exclosures significantly increase nest hatching success. Electrified exclosures can also be very effective at increasing hatching success under certain conditions, but at sites with high human disturbance and red fox densities, the proportion of exclosed nests that are abandoned by parental adults becomes sizeable. The direct cause of nest abandonments remains unclear since fox behavior on beaches and the dynamics of foxes and plovers at exclosures have not been studied. Our results suggest that such information is necessary if conservation practitioners can make more informed use of this direct management measure.

1. Introduction

Decision-making in conservation is predominantly experienced-based, with practitioners routinely drawing upon tradition, anecdotes, and existing management plans when organizing their own conservation directives (Pullin et al., 2004). Although experienced-based decisions can be successful under particular conditions, evidence-based decisions are more likely to be effective across varying conditions and can contribute to the construction of a solid scientific foundation upon which to advance biological conservation (Pullin and Knight, 2001). In many cases, management is implemented based on experience with the best of intentions but results in failure to meet management goals. In such instances it is nearly impossible to determine why the management failed. In the worst case scenario, the imposed management is a detriment to the target conservation organism(s). In this paper, we revisit the debate on the effectiveness of predator exclosures in increasing the hatching success of ground-nesting birds by examining a long-term monitoring data set for Atlantic Coast piping plovers (*Charadrius melodus*) in New Jersey, USA.

Ground-nesting birds, particularly shorebirds, have suffered drastic declines due to several anthropogenic factors, including habitat loss, habitat degradation, and human disturbance (e.g., Burger, 1981; Dolman and Sutherland, 1995; Dowding and Murphy, 2001). In addition to these threats, ground-nesters are susceptible to nest predation by both native and introduced species (e.g., Pauliny et al., 2008). Along the Atlantic coast, red foxes (*Vulpes vulpes*) and raccoons (*Procyon lotor*) are particularly injurious (Erwin et al., 2001; Neuman et al., 2004). In response to the severe decrease in reproductive success due to nest predation, several affected shorebird species have shifted their preference to other habitats where foxes were not present. Other beach-nesting species, such as piping and snowy plovers (*C. alexandrinus*), are incapable of successfully using alternative habitats due to their highly specialized cryptic plumage and the foraging requirements of their precocial chicks. Therefore, management strategies must be employed to counteract the negative impacts of mammalian predators on their reproductive success (Melvin et al., 1992; Neuman et al., 2004).

Electric fences that surround entire nesting areas have been used with varying success for piping plovers, least and Sandwich terns (Forster, 1975; Minsky, 1980; Mayer and Ryan, 1991; Murphy et al., 2003a; Ivan and Murphy, 2005), thus making this a potentially effective way of excluding ground predators. However, electric

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doi:10.1016/j.biocon.2009.07.034

fences are an expensive alternative and require a great deal of maintenance along dynamic shorelines. Further, municipalities are reluctant to allow the electrification of large areas of public beaches due to the potential electrical shock risk to humans and their pets (T. Pover, Conserve Wildlife Foundation of NJ, pers. comm.). Also, this method does not prevent avian predation, which is often a significant source of reproductive failure in these species (O'Connell and Beck, 2002).

The most popular method of predator control around shorebird nests is Rimmer and Deblinger's (1990) predator exclosure. Although some variation exists between studies, these exclosures generally consist of a galvanized wire cage surrounding the nest and anchored to the substrate. Exclosures are also topped with wire or plastic netting to prevent avian predators from accessing nests. Results of several studies indicate that predator exclosures have a significant positive effect on nest hatching success (Rimmer and Deblinger, 1990; Melvin et al., 1992; Estelle et al., 1996); however, other studies have challenged the effectiveness of predator exclosures, citing several drawbacks (e.g., Mabee and Estelle, 2000; Murphy et al., 2003b; Isaksson et al., 2007; Niehaus et al., 2004; Vaske et al., 1994).

Due to these conflicting outcomes, conservation practitioners may have great difficulty in determining whether or not to use predator exclosures in any particular situation. Thus, they may be more likely to retreat to 'common sense' strategies or anecdotal evidence to guide their actions (Sutherland et al., 2004). However, these personal experience approaches may be biased by uncommon yearly phenomena. Repeated predation events by a single nuisance individual at a breeding site in a given year may negatively bias inferences. Even a statistical analysis on a limited number of nests may lack the statistical power to generate a universal conclusion. Therefore, long-term analyses across several sites are warranted to generate a universal evidence-based decision on the employment of predator exclosures to protect the eggs of ground-nesting birds. Our analysis of 10 years of piping plover nesting data from the US state of New Jersey provides this needed long-term perspective.

Predator exclosures are routinely used in New Jersey to reduce predation of piping plover nests by red foxes and other mammals living in coastal habitats. Because of the lack of recovery within New Jersey and observational evidence that most nests are lost due to fox predation, at some sites piping plover nests are protected with an additional barrier consisting of electrified wire surrounding the exclosure, referred to here as an 'electrified exclosure'. This intensive management technique was first implemented to a limited extent in Maine in 1995, but no experimental tests or analyses were documented at that time (USFWS, 1996). Conservation practitioners in New Jersey adopted the practice at a small number of breeding sites, and beginning in 2004, electrified exclosures have been used routinely in some locations.

The use of electrified exclosures carries obvious direct risks to the parental birds, and has the potential to negatively impact nest survival in more obscure ways. Erection of these exclosures induces a longer period of stress to nesting adults during their construction. The electrical wire surrounding the nest can cause injury or death to adults if they come in contact with it. The likelihood of contact with the electrical wire is increased when the adult is active, as may be the case when they are disturbed by human activity or predators. Any feature of the nest site that increases adult activity therefore may result in abandonment of active nests. Our aim is to identify whether predator exclosures increase hatching success among piping plovers nesting on New Jersey's beaches, and whether electrifying exclosures results in increases in nest success above the effect of the non-electrified structure. We also explore the driving factors behind nest abandonments among those with electrified exclosures in order to assist managers in more selectively implementing this arguably extreme conservation measure.

2. Methods

2.1. Data collection

We obtained piping plover nest monitoring data from the New Jersey Division of Fish and Wildlife Endangered and Nongame Species Program (ENSP) for the years 1998–2007. Observers provided detailed accounts of each nest including: the day the nest was discovered, each day the nest was checked, the management technique(s) employed, and the fate of each nest. For failed nests, ENSP staff listed a presumed cause of failure (flooded, predated, abandoned). Additional information recorded by observers included a ranking of mammalian predator pressure based on the number of times evidence of a mammalian predator (i.e. tracks, scat) was observed within 10 m of the nest (0 = never, 1 = 1–3 times, 2 = 4–6 times, 3 = 7 + times), and the amount and types of recreational activities (i.e. sunbathing, jogging) that occurred within 50 m of the nest.

2.2. Study areas

Our nest survival analyses span the New Jersey coastline from Sandy Hook to the southern tip of New Jersey and include all beaches where piping plovers are known to breed. Predator exclosures are commonly used throughout the state. Electrified exclosures are predominantly used at three beaches in New Jersey – Gateway National Recreation Area – Sandy Hook Unit (Sandy Hook), North Brigantine Natural Area (Brigantine), and Corson's Inlet State Park (Corson's Inlet) (Fig. 1). Sandy Hook is a 10,500 hectare (ha) barrier spit that contains, in addition to beach, dune, and maritime forest habitats, a series of paved roads, parking lots, and public buildings. Brigantine is a 460 ha portion of a barrier island that consists of beach, dunes, and tidal marsh. Corson's Inlet is a 40 ha undeveloped portion of a barrier island that consists of beach and dunes.

2.3. Nest exclosure protocol

Managers of piping plover breeding sites within New Jersey follow a standardized exclosure protocol (USFWS, 1996). Exclosures consist of low-gage, galvanized wire positioned in an approximately 1.8 m diameter circle around each nest, extending approximately 20–25 cm belowground and upwards to a height of approximately 75–80 cm, topped with plastic netting. To electrify an exclosure, a single metal wire is connected to metal stakes arranged in a circle around (but not in contact with) the exclosure. The wire is then connected to a 6 V battery housed in a protective box and is grounded with an additional metal stake. All nests are exclosed and/or electrified within days of discovery, usually upon the completion of a full clutch. Once an exclosure is erected, the nest is closely monitored to ensure that parental adults accept it and resume incubation. If the adults do not accept the exclosure within approximately one hour, the structure is removed.

2.4. Nest survival (protected vs. unprotected nests)

We grouped all nests for which the fate was known by conservation treatment – unprotected, exclosed, and electrified – and calculated the percentage of abandoned nests for each study site and across all New Jersey breeding beaches. A nest was considered successful if at least one egg hatched. We then entered each group into Program MARK, which uses the Maximum Likelihood Estimator (MLE) of the daily survival rate (DSR) of each nest under a given conservation treatment (White, 2007). DSR is defined as the probability that a nest will survive one day. By raising the DSR estimate to the 35th power (equal to the average number of days in the lay-